

57. (amended) A substrate processing apparatus comprising:
a chamber comprising a radiation source;
one or more detectors to detect an intensity of the radiation reflected from a substrate or a chamber wall to generate a sample signal that may be used to determine a thickness of a layer on the substrate or chamber wall, and to detect a property of a radiation from the radiation source and generate a reference signal in relation to the property; and
a feedback controller adapted to regulate a power level of the radiation source in relation to the reference signal, wherein the feedback controller is adapted to maintain the property of the radiation at a substantially constant level.

REMARKS

Status of the Claims

Claims 1-4, 6-14, 23-30, 33-42, 44-51, and 57 to 59 are pending, of which claims 1-4, 6, 8, 23, 26, 30, 33-40, 42, 44-45, 47-49, 51 and 57 are being amended. Applicant requests entry of the amendments which are fully supported by the specification and original claims and add no new matter.

Applicant notes with appreciation, the Examiner's indication that claims 23-29 are allowable and that claims 5-10, 32-34 and 39 contain allowable subject matter. It should be noted that claim 23 is being amended to beautify the wording of the claim and not for reasons of patentability.

Reconsideration of the remaining claims in the application in view of the amendments and remarks herein is respectfully requested.

Rejections under 35 USC 102(b)

Sun et al

The Examiner rejected claims 1, 2, 3, 14, 40, 41 and 43 under 35 USC 102(b) as being anticipated by U.S. Patent No. 5,664,066 to Sun et al, hereinafter Sun et al.

Applicant respectfully traverses this rejection. Amended claim 1 is not anticipated by Sun et al because Sun et al does not disclose "one or more detectors to (i) detect an intensity of a first radiation originating from the radiation source and reflected from a substrate or chamber wall and generate a sample signal , and (ii) detect an intensity of a second radiation emitted from the radiation source and generate a reference signal". Instead, Sun et al discloses an apparatus for measuring the intensity of a number of different wavelengths (channels) of an optical spectrum produced by a plasma in a reaction chamber and evaluating the different wavelength intensities in a neural network. (Col. 10, line 50 to col. 11, line 6.) As taught by Sun et al, each channel covers a different wavelength in the optical spectrum produced by the plasma. (Col.13, lines 45-48.) At the section cited by the Examiner, namely column 14, lines 1-9, Sun et al teach removing background information from the optical spectrum produced by the plasma by measuring I_i (the input intensity value for channel i) and subtracting A_i (the nearby average intensity value for a small range of channels bracketing the channel i). (Col. 14, line 2.) It is clear that I_i and A_i as taught by Sun et al refer to the intensities of wavelengths in the optical spectrum produced by the plasma. Thus, Sun et al. does not disclose detecting an intensity of a radiation reflected from a substrate or chamber wall as recited in claim 1.

Furthermore, Sun et al. fails to disclose "a signal analyzer to normalize the sample signal relative to the reference signal to generate a normalized signal, and determine a thickness of a layer on the substrate or chamber wall from the normalized signal", as recited in claim 1. The thickness of the layer may be determined from the intensity of the reflected radiation, for example, by interferometric analysis. In contrast, Sun et al uses the normalized signal to control process parameters that affect the characteristics of the plasma process. Control of the process parameters is not the same as determining the thickness of a layer on the substrate or chamber wall. Thus, claim 1 is patentable over Sun et al.

Claims 2, 3 and 14 depend from claim 1 and include all limitations of the claim from which they depend, and thus are not anticipated by Sun et al for at least the same reasons as provided for claim 1.

Independent claim 40, as amended, is also not anticipated by Sun et al. Claim 40 is to a substrate processing apparatus comprising a chamber comprising a radiation source other than a plasma in a process zone in the chamber; one or more detectors to detect an intensity of a first radiation reflected from a substrate or a chamber wall to determine a thickness of a layer on the substrate or chamber wall, and detect an intensity of a second radiation from the radiation source; and a feedback controller adapted to regulate a power level of the radiation source in relation to the detected intensity of the second radiation.

As explained above, Sun et al disclose detecting radiation from an optical spectrum produced by a plasma in a chamber. Sun et al does not anticipate claim 40, as amended, because Sun et al does not disclose a detector for detecting an intensity of a first radiation reflected from a substrate or chamber wall to determine a thickness of a layer on the substrate or chamber wall. Nor does Sun et al does not disclose a

d tector to detect an intensity of a second radiation from *a radiation source other than plasma in a process zone in the chamber*. Sun et al also does not disclose a feedback controller adapted to regulate a power level of a radiation source other than a plasma, in relation to the detected intensity of the second radiation. In the Office Action, the Examiner has not explained the basis for the rejection of claim 40; but instead relies on the rejection of claim 1. As explained herein, claim 40 recites different language than claim 1, and accordingly, should not be rejected on the same basis as claim 1 without further explanation. Thus, claim 40, and claims 41 and 43 which depend from claim 40, are allowable over Sun et al.

Böbel et al

The Examiner further rejected claims 1, 2, 4, 11, 44-46, 48 and 49 under 35 USC 102(b) as anticipated by U.S. Patent No. 5,564,830 to Böbel et al.

Applicant respectfully traverses the rejection. Referring to claim 1, Böbel et al does not disclose, inter alia, "one or more detectors to ... detect an intensity of a second radiation emitted from the radiation source and generate a reference signal." Instead, Böbel et al teach "a first detector (7), provided for measuring the intensity of the thermal substrate radiation in a thermal-radiation-branch (B) and a second detector (8), provided in a reflectometer-branch (A) for detecting reflected radiation, namely radiation radiated from a source of light (6) and reflected from the wafer (1)." (Col. 2, lines 44-58.) Thus, Böbel et al teach measuring a thermal radiation emitted from the substrate and fail to teach a detector to generate a reference signal from a second radiation emitted from the same radiation source as that used to generate radiation for a reflected signal, as recited in claim 1.

Furthermore, Böbel et al. also do not teach "a signal analyzer adapted to normalize the sample signal relative to the reference signal to generate a normalized signal, and determine a thickness of a layer on the substrate or chamber wall from the normalized signal", as recited in claim 1. Instead, Böbel et al teach normalization of the pyrometer signal P and normalization of the reflectivity R of the substrate (Col. 3, lines 30-35 and lines 45-48.) Böbel et al further teach that the normalized pyrometer and reflectivity signals may be used to determine the temperature of the substrate. (Col. 3 line 57 to col. 4, line 12.) The resultant equation "allows for determination of the temperature without regard to the growing thickness of the layer or the lack of knowledge of the true material constants." (Col. 4, lines 8-12.) Normalization of the pyrometer signal P to determine the temperature of the substrate, is not the same as normalizing a sample signal relative to a reference signal to determine a thickness of a layer. Thus, claim 40 and the claims depending therefrom, are not anticipated by Böbel. et al.

Claim 44 is also not anticipated by Böbel et al. Claim 44 is to a substrate processing apparatus comprising, inter alia, "a first detector to detect a property of the radiation from the radiation source and generate a reference signal in relation to the property; a radiation modulator in a path of a radiation being transmitted from the radiation source to the chamber, the radiation modulator being adapted to receive the reference signal and control a property of the radiation in relation to the reference signal; and a second detector in a path of the radiation, the second detector capable of detecting an intensity of the radiation reflected from a substrate or a chamber wall to determine a thickness of a layer on the substrate or chamber wall."

Böbel et al. does not anticipate claim 44 because Böbel et al. fail to teach a detector that generates a reference signal in relation to a detected property of radiation from a radiation source, as claimed in claim 44. The reference signal is a

signal that may change in relation to the radiation from the radiation source, and that is used as a reference to control a property of the radiation from the radiation source. Also, Böbel et al. teach that a chopper modulates the intensity of the laser beam with a fixed frequency and not in relation to a reference signal from the detector. By teaching a modulator that modulates using a fixed frequency, Böbel et al. teach against modulating the intensity of a radiation with a reference signal that may vary in relation to a detected property of the radiation. For example, by modulating the radiation with such a reference signal, undesirable fluctuations of the radiation may be avoided or compensated for, thereby allowing a more accurate determination of the true value of the reflected radiation that is measured by the second detector recited in claim 44. Thus claim 44 is not anticipated by Böbel et al., and claims 45, 46, 48 and 49 which depend upon claim 44, are also not anticipated for at least the same reasons as claim 44.

Betz et al

The Examiner rejected claims 44, 45, 46, 48, and 49 under 35 U.S.C. 102(b) as being anticipated by U.S. Patent 4,838,694 to Betz et al. (Betz et al.). This rejection is respectfully traversed.

Betz et al. does not anticipate claim 44 because Betz et al. fails to teach a detector that generates a reference signal in relation to a detected property of the radiation, as claimed in claim 44. Instead, Betz et al. teach an imaging laser interferometer that uses a detector to detect the intensity of combined reflected laser beams and transforms the optical information into data signals. Betz et al. also fails to teach "a radiation modulator capable of receiving the reference signal from the detector and modulating the property of the radiation beam according to the reference signal." Instead, Betz et al. teaches that a modulator modulates the intensity of the laser beam

with a fixed frequency and not according to a reference signal from the detector. By teaching a modulator that modulates using a fixed frequency, Betz et al. teaches against modulating the intensity of a radiation with a reference signal that may vary in relation to a detected property of the radiation. Thus, claim 44 and the claims dependent therefrom, including claims 45, 46, 48, and 49, are allowable.

Rejections under 35 USC 103(a)

Sun et al

The examiner rejected claims 42 and 57-59 under 35 USC 103(a) as being unpatentable over Sun et al. Applicant traverses the rejection.

Claims 42 is not obvious over Sun et al. Claim 42 is dependent from claim 40 and is therefore allowable for the same reasons as given above for claim 40. For example, claim 40 is allowable because Sun et al does not disclose a detector for detecting an intensity of a first radiation reflected from a substrate or chamber wall to determine a thickness of a layer on the substrate or chamber wall. Nor does Sun et al does not disclose a detector to detect an intensity of a second radiation from *a radiation source other than a plasma in a process zone in the chamber*. Sun et al fails to teach or suggest a radiation source other than a plasma in the process zone. Absent a specific teaching or suggestion to modify the reference to use a radiation source other than a plasma, the Examiner cannot establish a prima facie case of obviousness. In addition, claim 42 recites a feedback controller adapted to maintain a property of the radiation at a substantially consistent level. Sun et al does not teach maintaining the radiation at a substantially constant level. Therefore, Sun et al does not render claim 42 unpatentable. Sun et al also does not disclose a feedback controller adapted to

regulate a power level of a radiation source other than a plasma, in relation to the detected intensity of the second radiation.

Sun et al. fails to render claim 57 obvious because Sun et al fail to teach or suggest a substrate processing apparatus comprising, inter alia, "one or more detectors to detect an intensity of the radiation reflected from a substrate or a chamber wall to generate a sample signal that may be used to determine a thickness of a layer on the substrate or chamber wall, and to detect a property of a radiation from the radiation source and generate a reference signal in relation to the property; and a feedback controller adapted to regulate a power level of the radiation source in relation to the reference signal, wherein the feedback controller is adapted to maintain the property of the radiation at a substantially constant level." Instead, Sun et al discloses an apparatus for measuring the intensity of a number of different wavelengths (channels) of an optical spectrum produced by a plasma in a reaction chamber and evaluating the different wavelength intensities in a neural network. (Col. 10, line 50 to col. 11, line 6.) Sun et al determines a normalized signal to control process parameters that affect the characteristics of the plasma process. Control of the process parameters is not the same as determining the thickness of a layer on the substrate or chamber wall. Thus, claim 57 and the claims dependent therefrom are not obvious over Sun et al.

Böbel et al

The Examiner further rejected claims 12, 13, 38 and 51 under 35 USC 103(a) as being unpatentable over U.S. Patent No. 5,564,830 to Böbel et al. Applicant traverses the rejection.

Claims 12, 13, 38, and 51 are not obvious over Böbel et al. Each of claims 12, 13, 38 and 51 recite a radiation transmitting fiber capable of transmitting a radiation to a detector. Böbel et al does not teach a radiation transmitting fiber, nor does the reference suggest to one of ordinary skill that it would be desirable to use such a radiation transmitting fiber. In addition, it is not clear how such a fiber would be incorporated, since in Böbel et al the same radiation pathway is used to transmit a first radiation and a thermal radiation to a detector. Thus, Böbel et al does not render claims 12, 13, 38, and 51 unpatentable and the rejection is requested to be withdrawn.

In addition, claims 12 and 13 are dependent on claim 1 and are therefore allowable for the same reasons as given above for claim 1. For example, Böbel et al. do not teach "a signal analyzer adapted to normalize the sample signal relative to the reference signal to generate a normalized signal, and determine a thickness of a layer on the substrate or chamber wall from the normalized signal", as recited in claim 1. Instead, Böbel et al teach normalization of the pyrometer signal P and normalization of the reflectivity R of the substrate (Col. 3, lines 30-35 and lines 45-48.) Normalization of the pyrometer signal P to determine the temperature of the substrate, is not the same as normalizing a sample signal relative to a reference signal to determine a thickness of a layer. Thus, claims 12 and 13 are not obvious over Böbel et al..

Claim 38 is also not obvious over Böbel et al. because claim 38 recites, inter alia, "a reference detector to detect a reference radiation from the plasma and generate a reference signal ... and one or more fibers to transmit the reference radiation to the reference detector, the fibers arranged to receive reference radiation which is not reflected from the substrate." Böbel et al. fail to teach or suggest a reference detector to detect a reference radiation from the plasma and generate a reference signal. Böbel et al. also fail to teach one or more fibers to transmit the reference radiation to the reference detector, the fibers arranged to receive reference

radiation which is not reflected from the substrate. Thus, claim 38 and the claims dependent therefrom are not obvious over Böbel et al.

Claim 51 is dependent on claim 44 and is therefore also allowable for the same reasons as claim 44 is allowable, as provided above. For example, Böbel et al. fail to teach or suggest a detector that generates a reference signal in relation to a detected property of radiation from a radiation source, as claimed in claim 44. Instead, Böbel et al. teach that a chopper modulates the intensity of the laser beam with a fixed frequency and not in relation to a reference signal from the detector. By teaching a modulator that modulates using a fixed frequency, Böbel et al. teach against modulating the intensity of a radiation with a reference signal that may vary in relation to a detected property of the radiation. Thus claim 51 is not obvious over Böbel et al..

Böbel et al in view of van Pham

The Examiner rejected claims 12, 13, 30, 31, 35-38 and 51 under 35 USC 103(a) as being unpatentable over Böbel et al in view of U.S. Patent No. 4,776,695 van Pham et al, hereinafter van Pham et al.. Applicant traverses the rejection.

Each of claims 12, 13, 30, 31, 35-38, and 51 recite a radiation transmitting fiber capable of transmitting a radiation to a detector. As discussed above, Böbel et al does not teach or suggest a radiation transmitting fiber. In addition, it is not clear how such a fiber would be incorporated in Böbel et al since the same radiation pathway in Böbel et al is used to transmit a first radiation and a thermal radiation to a detector. van Pham et al teaches a fiber optic bundle capable of light transmission, but does not teach the transmission configuration set forth in the claims. Böbel et al specifically teaches an arrangement of the objective, filter, radiation splitters and lens that is made such that the thermal radiation and the reflected radiation of the light source are

incident on both detectors (Col. 6, ln. 12-16). Thus, one of ordinary skill in the art would not have been motivated to replace the specific arrangement of Böbel et al with a fiber, absent clear suggestion to do so.

In addition, claims 12 and 13 are dependent on claim 1 and are therefore allowable for the same reasons as given above for claim 1.

Claim 30 is being amended to include the limitations of claim 32, which the Examiner indicated would be allowable if rewritten in independent form. Thus, claim 30 and the claims dependent therefrom are allowable over Böbel et al.

Claim 38 is also allowable over Böbel et al. because Böbel et al. recites a substrate processing apparatus comprising, inter alia, "a reference detector to detect a reference radiation from the plasma and generate a reference signal." Böbel et al. fail to teach one or more fibers to transmit the reference radiation to the reference detector, the fibers arranged to receive reference radiation which is not reflected from the substrate, and also fail to teach a reference detector to detect a reference radiation from the plasma and generate a reference signal. Thus, claim 38 and the claims dependent therefrom are allowable.

Claim 51 is also dependent on claim 44 and is therefore allowable for the same reasons as claim 44 is allowable, as provided above.

Claims 47 and 50

Claims 47 and 50 were not specifically addressed in the body of the Office Action mailed on October 20, 2000. Accordingly, Claims 47 and 50 are believed to be allowable.


Conclusion

The claims are allowable at least for the reasons given above. The Examiner is respectfully requested to reconsider the present rejections and allow the pending claims. Should the Examiner have any questions, the Examiner is requested to call the undersigned representative of the Applicant.

Respectfully submitted,

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1. (twice amended) A substrate processing apparatus comprising:
 - (a) a chamber comprising a radiation source;
 - (b) one or more detectors to (i) detect an intensity of a first radiation originating from the radiation source and reflected from a substrate or a chamber wall and generate a sample signal, and (ii) detect an intensity of a second radiation emitted from the radiation source and generate a reference signal; and
 - (c) a signal analyzer adapted to normalize [a property of the first radiation relative to a property of the second radiation] the sample signal relative to the reference signal to generate a normalized signal, and determine a thickness of a layer on the substrate or chamber wall from the normalized signal.
2. (amended) An apparatus according to claim 1 wherein the detectors are adapted to detect substantially the same [property] wavelength of the first and second radiation[, the property comprising one or more of an intensity, phase or wavelength].
3. (amended) An apparatus according to claim 1 wherein the detectors are adapted to detect [the] a wavelength of the first and second radiation that is suitable to determine an endpoint of the process.
4. (amended) An apparatus according to claim 1 comprising a first detector to detect [a] the intensity of the first radiation [that is reflected in the chamber and generate a sample signal;] and a second detector to detect [a] the intensity of the second radiation [from the radiation source and generate a reference signal].
6. (amended) An apparatus according to claim [5] 1 wherein the signal analyzer normalizes the reference and sample signals by determining a ratio of the signals.

8. (amended) An apparatus according to claim 7 wherein the signal analyzer determines [a] the corrected sample signal, X_m , using the expression $X_m = X_t / \{Y_0 + C(Y_t - Y_0)\}$,

where C is the correction factor, Y_0 is the reference signal at time 0, X_t is the sample signal at time t, and Y_t is the reference signal at time t.

23. (amended) A substrate processing apparatus comprising:

(a) a chamber capable of processing a substrate, the chamber comprising a radiation source;

(b) a detector to detect a reflected radiation from the substrate or a chamber wall and generate a sample signal; and

(c) a signal analyzer adapted to receive the sample signal and determine a corrected sample signal, X_m , using the expression $X_m = X_t / \{Y_0 + C(Y_t - Y_0)\}$,

where C is [the] a correction factor, Y_0 is [the] a reference signal at time 0, X_t is the sample signal at time t, and Y_t is the reference signal at time t.

26. (amended) An apparatus according to claim 23 wherein the detector is adapted to detect a radiation originating from the radiation source and generate [a] the reference signal, and wherein the signal analyzer is adapted to receive the reference signal and determine a normalized signal from the sample and reference signals.

30. (amended) A substrate processing apparatus comprising:

- (a) a chamber capable of processing a substrate, the chamber comprising a radiation source;
- (b) a sample detector to detect a reflected radiation from the substrate or a chamber wall and generate a sample signal;
- (c) a reference detector to detect a reference radiation from the radiation source and generate a reference signal; and
- (d) one or more first fibers to transmit the reference radiation from the radiation source to the reference detector and one or more second fibers to transmit the reflected radiation from the radiation source to the chamber, the first and second fibers arranged to receive radiation from one or more areas of the radiation source that have about the same size.

33. (amended) An apparatus according to claim [32] 30 wherein the areas are from the same region of the radiation source.

34. (amended) An apparatus according to claim [31] 30 wherein the first and second fibers are arranged to have substantially overlapping field of views.

35. (amended) An apparatus according to claim [31] 30 wherein the first fibers lead directly from the radiation source to the reference detector.

36. (amended) An apparatus according to claim [31] 30 further comprising a lens to focus the reference radiation from the radiation source onto the first fibers.

37. (amended) An apparatus according to claim [31] 30 further comprising a signal analyzer to receive the reference and sample signals and normalize one relative to the other, and optionally, to correct the sample signal for background radiation.

38. (amended) A substrate processing apparatus comprising:

- (a) a chamber capable of processing a substrate, the chamber comprising a radiation source that includes a plasma;
- (b) a sample detector to detect a reflected radiation from [a] the substrate [in the] or a chamber wall and generate a sample signal;
- (c) a reference detector to detect a reference radiation from the plasma and generate a reference signal; and
- (d) one or more [first] fibers to transmit the reference radiation to the reference detector, the fibers arranged to receive reference radiation which is not reflected from the substrate.

39. (amended) An apparatus according to claim 38 wherein the [second] fibers receive reference radiation that is viewed from the side of the plasma, or that is viewed from an angle [of the plasma] which is not from directly above the substrate.

40. (twice amended) A substrate processing apparatus comprising:

- (a) a chamber comprising a radiation source other than a plasma in a process zone in the chamber;
- (b) [a detector] one or more detectors to detect an intensity of a first radiation reflected from a substrate or a chamber wall to determine a thickness of a layer on the substrate or chamber wall, and detect [a property] an intensity of a second radiation from the radiation source; and
- (c) a feedback controller adapted to regulate a power level of the radiation source in relation to the detected [property] intensity of the second radiation.

42. (twice amended) An apparatus according to claim 40 wherein the feedback controller is adapted to maintain the [property] intensity of the second radiation at a substantially constant level.

44. (twice amended) A substrate processing apparatus comprising:

- (a) a chamber;
- (b) a radiation source capable of generating a radiation;
- (c) a first detector to detect a property of [a] the radiation from the radiation source and generate a reference signal in relation to the property; [and]
- (d) a radiation modulator in a path of a radiation being transmitted from the radiation source to the chamber, the radiation modulator being adapted to receive [a signal from the radiation source] the reference signal and control a property of the radiation in relation to the reference signal; and
- (e) a second detector in a path of the radiation, the second detector capable of detecting an intensity of the radiation reflected from a substrate or a chamber wall to determine a thickness of a layer on the substrate or chamber wall.

45. (amended) An apparatus according to claim 44 wherein the first detector is adapted to detect a property of the radiation comprising one or more of an intensity, phase or wavelength.

47. (amended) An apparatus according to claim [44] 46 wherein the radiation modulator is adapted to maintain the intensity of the radiation at a constant level.

48. (amended) An apparatus according to claim [44] 46 wherein the radiation modulator comprises a shutter, mirror, or variable density screen.

49. (amended) An apparatus according to claim [48] 46 wherein the radiation modulator comprises a means for partially attenuating the radiation.

51. (amended) An apparatus according to claim 44 wherein the radiation is transmitted to the first detector by one or more radiation transmitting fibres.

57. (amended) A substrate processing apparatus comprising:

a chamber comprising a radiation source;

[a] one or more detectors to detect an intensity of the radiation reflected from a substrate or a chamber wall to generate a sample signal that may be used to determine a thickness of a layer on the substrate or chamber wall, and to detect a property of a radiation from the radiation source and generate a reference signal in relation to the property; and

a feedback controller adapted to regulate a power level of the radiation source in relation to the [detected property of the radiation] reference signal, wherein the feedback controller is adapted to maintain the property of the radiation at a substantially constant level.